## REMARKS

This Response is submitted in response to the Office Action dated October 17, 2008. Claims 1-10 were previously cancelled. Claim 11 has been amended to correct a typographical error. Claims 11-20 stand rejected under 35 U.S.C. §103(a). Applicants respectfully disagree with and traverse the rejections for at least the reasons below. The Commissioner is hereby authorized to charge deposit account 02-1818 for any fees which are due and owing.

In the Office Action, claims 11-20 are rejected under §103(a) as being unpatentable over over U.S. Patent No. 5,250,167 to Adolf et al. ("Adolf"), in view of Hirai et al. ((2003) Proc. of SPIE 5051: 198-206), U.S. Patent No. 6,249,076 to Madden et al. ("Madden"), and U.S. Patent No. 6,475,637 to Shahinpoor et al. ("Shahinpoor").

Of the rejected claims, Claim 11 is the sole independent claim. Claim 11 recites, at least in part, a polymer actuator including: a plurality of gel/electrode complexes arranged in an electrolytic aqueous solution, each of said gel/electrode complexes being composed of a polymer gel *containing at least one of acidic and basic functional groups* and electrodes placed in the polymer gel, said electrodes being made of a material capable of *occluding and releasing hydrogen electrochemically*, such that the polymer gel in each gel/electrode complex changes in pH upon application of voltage across the electrodes of the gel/electrode complexes, and each of the gel/electrode complexes changes in volume in response to the pH change.

One nonlimiting example of the presently claimed invention is illustrated in Figs. 2A and 2B of the present application. In this example, the polymer actuator 1 includes a container 5 having flexible walls and ends 5'. (See, Figs. 2A and 3B). Housed in container 5 are two gel/electrolyte complexes 4a and 4b. The gel/electrolyte complexes 4a and 4b each include a polymeric hydrogel 2a and 2b having basic or acidic functional groups. An electrolyte aqueous solution 6 surrounds the gel/electrolyte complexes 4a and 4b within the container 5. As shown in Figs. 2A and 2B, the electrodes 3a and 3b are placed in and extend through the gel/electrolyte complexes 4a and 4b. In this example, the electrodes 3a and 3b are coil shaped and stretch or expand along with the hydrogel 2a and 2b when the polymeric actuator 1 is expanded. As shown in Figs. 2A and 3B, the cathode 3b and the anode 3a are located on the same side of the polymeric actuator 1.

Critical to understanding this claim is recognizing the response to pH changes of the plurality of gel electrode complexes. One gel electrode complex has an acidic functional group. At a certain pH the acidic groups are protonated, but upon lowering the pH form hydrogen bonds with one another, resulting in a contraction of the acidic gel electrode complex. At the same time, the pH increases at the basic gel/electrode complex. At this site, basic groups are not protonated but do form strong hydrogen bonds with each other, leading to a contraction of the basic gel electrode complex.

Moreover, the pH change in the current invention is achieved by the occlusion and release of hydrogen from the electrode, not from electrolysis of water that occurs in aqueous solutions between an anode and a cathode. Consequently, the evolution of gases (hydrogen and oxygen) is avoided, and water is not consumed. The occlusion and release of hydrogen then changes the volume of the gel/electrode complex, leading to mechanical action.

Applicants assert that the cited references fail to disclose or suggest each and every aspect of the claimed invention, that the references are not properly combinable or have been improperly combined based on hindsight analysis, and that even if properly combinable do not achieve the advantages of the currently claimed invention.

The references on which the Examiner relies do not teach each and every aspect of the claimed invention. As noted in the prior response, Adolf discloses electrically controlled polymeric gel actuators. As shown in Fig. 1 and Fig. 1a, polymeric gel actuator 10 is shown in its contracted and expanded states, respectively, and includes hermetically sealed cylindrical shell structure 12, having a flexible wall 14 and end plates 16 and 18. (See, Adolf, col. 1, lines 49-68). Shell structure 12 contains an electrolytic solution 20 such as a 1.0 weight percent solution of NaCl in water. (See, Adolf, col. 1, lines 49-68). And the motive power is provided by swelling or contraction of the gel due to the absorption or desorption of solvent in response to a pH change. This solvent requirement is one of the limitations understood to exist in this technology, as noted by the prior art. Excess solvent requires a reservoir, and in some cases a circulating system, adding to bulk in the system. In contrast, the claimed invention increases its volume via repulsions and attractions within the gel without the need for excess solvent.

Also note that Adolf fails to disclose use of a palladium catalyst or a coil/mesh structure as an electrode structure. Moreover, Adolf fails to disclose or suggest electrodes placed in the

polymer gel, as recited in amended Claim 11. As discussed above, Adolf discloses the anode 18 and cathode 16 on separate ends of the actuator 10. There is no disclosure of electrodes being placed in the polymer gel itself, or extending through the polymer gel as in the example described above with regard to the present application.

Finally, Adolf does not disclose an electrode material capable of occluding and releasing hydrogen. In fact, Adolf achieves a pH changes by creating a pH gradient in the aqueous solution, not by adding or releasing hydrogen to the system. This technique is severely limited and is one of the issues the current system was designed to overcome. An application of voltage across an aqueous system creates a pH gradient by electrolysis of water, not the occlusion and release of hydrogen. Consequently, this results in oxidation near the anode, effectively lowering the pH of the solution and generating oxygen gas, and reduction near the cathode that raises the pH and generates hydrogen gas. A closed system is hampered by the production of these gases.

Hirai does not cure the deficiencies in Adolf. The Examiner relies on Hirai for teaching the creation of polymer gel/electrode actuators using a range of gels, discussing the merits and bending capabilities of different gel types. This statement overstates the disclosure of Hirai. Hirai teaches non-ionic polymer gels with no explicit chemical reaction or chemical consumption, suggesting that these dielectric gels can be more effective. P 199, first paragraph. The examples further distinguish Hirai from the currently claimed acidic and basic gel polymers– the polymers disclosed by Hirai are polyvinyl alcohol (2.1.1), plasticized polyvinyl chloride (2.1.2), and polyurethane elastomer (2.1.3). The characteristicsof these non-acidic, non-basic gels are studied in great detail, but none of these gels reads on any element of the claimed invention. The Examiner also states that Hirai teaches electrodes on both sides of the gel container, citing Figure 10. This is exactly the opposite of the claimed invention, wherein the electrode is placed within the polymer gel. Again, the voltage difference spanning the two electrodes can lead to electrolysis of the solution and consumption of water. Furthermore, there is no discussion about the electrodes ability to occlude or release hydrogen. Finally, the Examiner notes that Hirai mentions "dopants" such as amine and carboxyl groups added to the polymer gels to control redox. This comment is irrelevant because the claim requires each polymer gel to having one of the functional groups, not just some acid or base tossed into the

mixture. In summary, Hirai provides none of the elements of the claimed invention, and certainly fails to cure the deficiencies of Adolf.

Madden fails to cure the deficiencies of Adolf. The mechanism of action of the actuator in Madden is completely different from Adolf, and completely irrelevant to the presently claimed invention. Madden teaches using an electrode, including palladium to produce an electrical potential across an active member, wherein the active member includes a conductive polymer. The active member then has an apparent repulsive or attractive effect to a counterelectrode that provides the electromotive force. The conductive polymers are polymers typically with extended $\pi$-electron conjugated systems, such as polypyrole or polyaniline.

Madden does not teach a plurality of gel/electrode complexes composed of polymer gels. In fact, Madden teaches away from polymer gels. "Note that conducting polymers are different from other electro-responsive polymers described in the literature. Polymers described, for example, in U.S. Pat. No. 5,389,222, entitled "Spring-Loaded Polymeric Gel Activators" to Shahinpoor, and in U.S. Pat. No. 5,100,933, entitled "Collapsible Gel Compositions" to Tanaka, are gels and are not electronically conductive. Any conduction exhibited by these gels occurs strictly by the transfer of ions. In contrast, in conducting polymers, charge is transported along the polymer backbone and between chains...." Madden, Col 3. lns. 16-24. Madden specifically teaches away from polymer gels and is therefore irrelevant as prior art, and certainly not combinable with Adolf. Moreover, Madden does not teach the polymer gel with acidic functional groups. Moreover, Madden obviously does not teach an electrode immersed in the gel, given that there is no gel.

Finally, Shahinpoor is relied on for the alleged disclosure of "a porous conductive layer embedded in said polymer with penetration inside said polymer comprising at least two embedded electrodes wherein application of an electric potential across said electrodes causes movement of said polymer *in a dry environment*." (See, Office Action, pg. 4, emphasis added). Applicants note that the primary Adolf reference is discussed in detail in the background section of Shahinpoor. (See, col. 2, lines 21-39). In particular, Shahinpoor appears to tout the disadvantages of using polymeric gels: "the disadvantage is that actuator performance is dictated by the parameters of the polymeric gel used ... furthermore, liquid containment is required to make the actuators stronger and not so easily broken." (See, Shahinpoor, col. 2, lines 35-39). In

addition, Shahinpoor discloses that "the sensors of the present invention also have a very broad bandwidth and can sense oscillatory motion at rates of up to hundreds of Hz, unlike most polymeric gels." (See, Shahinpoor, col. 14, lines 4-7). Accordingly, not only does Shahinpoor fail to disclose or suggest an electrode in a polymer gel, but Shahinpoor does not appear to be properly combinable with Adolf because it teaches away from Adolf.

Applicants also respectfully submit that the reliance on a coil structure in Shahinpoor is misplaced, where the Adachi reference disclosed in col. 3, lines 19-26 of Shahinpoor relates to a completely different field of endeavor and it appears that the "coil" structure does not even relate to an electrode, much less an electrode that is placed in a gel/electrolyte complex, as recited in the present claims.

The combination of the references, even if properly combinable, requires the use of improper hindsight. In order to craft an obviousness rejection, the Examiner has relied on no less than four references, selectively picking and choosing elements from each of those disclosures to build the Applicants' claimed actuator. Ignoring for the moment that many of the elements selected by the Examiner do not actually contain the characteristics the Examiner ascribes to them, such picking and choosing of elements from multiple sources is improper hindsight analysis. As asserted in the Office Action,

> "it would have been obvious ... to combine the teachings of Adolf, Hirai, Madden, and SHahinpoor, along with many other prior art teachings as enumerated in each of these, to create a polymer actuator using a gel/electrode complex. Various configurations of gel, electrode, chemical reactions, and structures would be known in the art to provide the most motive force with the most stable system. As Hirai state[d], 'the concept proposed is simple and can be applied to a wide range fo materials".... One would have a reasonable expectation of success in creating a gel/electrode actuator using the various systems as described in the prior art since many variations were already known and information on the construction, use, force available, reliability, and durability of various configureations was publically available.

Final Office Action, page 4. However, despite the alleged obviousness of the claimed invention in view of all the prior art, the Examiner has not been able to cite a reference where someone else has made this invention, nor a reference describing the occlusion and release of hydrogen from an electrode contained within a polymer gel. The lack of these elements and the need to cite to four references, not to mention "many other prior art teaching,s" suggests that in fact the claimed invention was not obvious.

For at least the reasons above, Applicants respectfully request withdrawal of the 35 U.S.C. §103(a) rejections of Claims 11-20. Accordingly, Applicants respectfully submit that the present application is in condition for allowance and earnestly solicit reconsideration of same.

Respectfully submitted,

BELL, BOYD & LLOYD LLP

BY _____
Thomas C. Basso
Reg. No. 46,541
Customer No. 29175

Dated: December 19, 2008